



## Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at <http://about.jstor.org/participate-jstor/individuals/early-journal-content>.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

# SCIENCE

NEW YORK, MAY 22, 1891.

## THE TEACHING OF SCIENTIFIC METHOD.<sup>1</sup>

THE title of the address which I am privileged to deliver this evening has been advisedly chosen, in order to mark the contrast between the teaching of what is commonly called "science" and the teaching of "scientific method." It is, I think, to the failure to discriminate between these that the delay of which we so bitterly complain in introducing experimental studies into schools generally is largely attributable.

For years past the educational world has been witness of conflicts innumerable. Its time-honored and most cherished dogmas and practices have been subjected to severely searching criticism, and it cannot be denied that they have often-times emerged from the battle in a terribly mangled condition; nevertheless they have hitherto manifested a marvellous recuperative power. Modern subjects, especially experimental science, have as yet barely obtained a foothold in our schools, and their educational effect has been scarcely appreciable; nay, it is even said, and probably with too much of truth, that the results under our present — may I not say — want of system are inferior to those obtained in the purely classical days of yore, when the scholars' efforts were less subdivided, when fewer subjects claimed their attention. The net upshot of discussion simply has been that we are intensely dissatisfied with our present position, and that we realize that some change has to be made. What that change is, we are not yet agreed. This, after all, is a very healthy state to be in, and one which necessarily must precede the construction of a satisfactory programme of studies suited to the vastly changed conditions under which the work of the world has been carried on since those two potent agents, steam and electricity, have assumed sway.

In setting our house in order, one great difficulty arises from the multitude of counsellors. Every subject in turn asserts its soul-saving power, and puts forth its claim on a portion of the school time. An infinite number of suggestions are made. Who is to arbitrate in so difficult a case? Certainly, the more I study the educational problem, the more I realize the extraordinary difficulties which it presents. We are not all cast in one fixed mould, and cannot all be made alike. Educational rules must necessarily be made infinitely elastic, and educational success can only be achieved by the elastic administration of rules.

But are those who are charged with the conduct of so difficult a mission in any way specially prepared for the campaign? Suppose at a largely attended representative meeting of British teachers some one were to discourse in most eloquent terms of the beauties of the Chinese language, and were to affirm in the most positive manner possible that no other language offered the same opportunity of inculcating lessons of the highest import, what would be the result? Few, if any, present would know a word of the language; and therefore, although all might agree that they had listened

to a most learned and interesting discourse, the effect would be ephemeral, and the advice given would be wholly disregarded by the majority. Never having had occasion to study the language, they probably would mentally set down the lecturer as a *doctrinaire*, — as a member of that troublesome and objectionable class, the enthusiasts, who are always interfering with other people's business and trying to lead them to mend their ways. Some few might think it politic to include Chinese in their school programme. These would either purchase a "Reader," and endeavor to master the subject themselves sufficiently to impress a smattering of information on a limited number of pupils in perhaps the higher forms in their schools, or would engage a young fellow fresh from the university as teacher, who had little more than mastered the principles of the Chinese alphabet, but was considered capable of anything because he had taken a good degree. I very much fear that the treatment which I picture as accorded to my hypothetical subject, Chinese, is very much the kind of treatment meted out to experimental science in most schools. In the majority of cases it has been included in the programme because it has become fashionable and is a subject in which public examinations are held, more or less under compulsion, and without real belief in its worth or efficacy as an educational instrument. It is not surprising, therefore, that the results have been so unsatisfactory.

Two causes appear to me to operate in retarding educational progress. In the first place, our schools, with scarcely an exception, are controlled by our ancient universities; and these, I think, are not improperly described as, in the main, classical trades-unions. The majority of those who pass through their courses are required only to devote their attention to purely literary studies, and, unless by accident, they acquire no knowledge of the methods of natural science: consequently, having no understanding of, they exhibit no sympathy with, its aims and objects. It is a strange fact that so limited and non-natural a course of training should alone be spoken of conventionally as "culture," and that it should count as no sin to be blind to all that is going on in the world of nature around us, and to have no appreciation or understanding of the changes which constitute life, — no knowledge of the composition and characters of the materials of the earth on which we dwell. As the entire body of teachers in the more important of our schools are university men, and the examples which such schools set permeate into and pervade schools generally, the result of the introspective system of training followed at our universities is disastrous. That the effect of a change in the present university system on scholastic opinion and practice would be far-reaching, has been clearly realized. In proof of this, I may again cite remarks made by the present head master of Rugby, formerly head master of Clifton College, which I quoted in my address to the Chemical Section of the British Association at Aberdeen in 1885: they were made at a meeting of convocation at Oxford a few months previously. Dr. Percival said, "If twenty years ago this university had said, from this time forward the element of natural science shall take their place in responses, side by side with the elements of

<sup>1</sup> Paper read by Professor Henry E. Armstrong at a meeting of the British College of Preceptors, April 8, 1891.

mathematics, and shall be equally obligatory, you would long ago have effected a revolution in school education." Reading between the lines, I imagine that Dr. Percival would imply that such action of the university would have led schools generally to pay attention to natural science, just as they do to mathematics, and that the general public would thereby also have been led to appreciate such studies. Charles Kingsley gave utterance to similar thoughts when he said, "I sometimes dream of a day when it will be considered necessary that every candidate for ordination should be required to have passed creditably in at least one branch of physical science, if it be only to teach him the method of sound scientific thought." Evidently Kingsley was of opinion that the teaching of his day was not always conducive to habits of "sound scientific thought." Has it been much improved in the interval? There are a few who cannot realize what would be the effect of neglecting to teach the elements of mathematics: Dr. Percival's advice that the elements of natural science should be made equally obligatory is therefore pregnant with meaning. All can imagine what difficulty would be created at Cambridge, for example, if those who went up wishing to study mathematics had no acquaintance with even the first four rules of arithmetic, but such is the position, owing to the neglect of natural science in schools, in which those of us find ourselves who are called on to teach science in colleges and at the universities; and the result is, that the time which should be devoted to the study of the higher branches of a subject is wasted in teaching elementary principles, more often than not, to unwilling minds unprepared to assimilate knowledge involving studies of an entirely novel character.

But, beyond the difficulties created by the low standard of scholastic and public opinion as regards natural science, there is a second retarding cause in operation, for the existence of which we teachers of natural science are in a great measure responsible, and which it behooves us to remove. I refer to the absence of any proper distinction between the teaching of what is commonly called "science" (i.e., facts pertaining to science) and the teaching of scientific method. The dates at which our various kings reigned, the battles they fought, and the names of their wives, are facts pertaining to history, and it is not so very long since such facts alone were taught as history. Nowadays such facts are but incidentals in a rational course of historical study, and it is clearly realized that the great object is to inculcate the use of such facts,—the moral lessons which they convey. "And if I can have convinced you that well-doing and ill-doing are rewarded and punished in this world, as well as in the world to come, I shall have done you more good than if I had crammed your minds with many dates and facts from modern history" (conclusion of Kingsley's lectures on America at Cambridge in 1862), are words which aptly convey an idea of one of the chief purposes gained in teaching history, and by which the methods of teaching it are being moulded. In like manner, to inculcate scientific habits of mind,—to teach scientific method,—we must teach the use of the facts pertaining to science, not the mere facts. Again, in teaching history in schools, we recognize that the subject must be broadly handled, and attention directed to the salient points which are of general application to human conduct: the study of minutiae is left to the professed historian. But the very reverse of this practice has been followed, as a rule, in teaching natural science in schools. At various times during recent years—at the Educational Conference held at the Health Exhibition in 1884, and at the British Association

meeting in 1885—I have protested against the prevailing system of teaching chemistry, etc., to boys and girls at school as though the object were to train them all to be chemists; and I have also protested against the undue influence exercised by the specialist,—an influence which he has acquired in consequence of the inability of the head of the school to criticise and control his work. I refer here as much to the examiner as to the teacher; indeed, more. It appears to me to be our duty to regard all questions relating to school education from a general point of view, to consider what is most conducive to the general welfare of the scholar; and in allowing the specialist access to the school, the greatest care must be taken that the subject treated of is dealt with in a manner suited to the requirements of the scholars collectively. It is only in the case of technical classes that supreme control can be vested in the specialist.

In order that we may be in a position to usefully criticise the educational work which is being done, and the proposals brought forward, it is essential to arrive at a clear understanding of the objects to be achieved. Much of the work in a school is done with the object of cultivating certain arts (mechanical arts, we may almost call them),—the art of reading, the art of writing, and the art of working elementary mathematical problems, until the operations involved are efficiently performed in an automatic manner. An elementary acquaintance with these arts having once been gained, all later studies may be said to originate naturally in them,—both those which lead to the acquisition of knowledge, and those which have for their ultimate object the development and training of mental faculties. The character and extent of these later studies is subject to great variation, according as individual requirements, opportunities, and mental peculiarities vary; but the variation is not usually permitted to take place until a somewhat late period in the school career. We recognize, in fact, that in the case of every individual the endeavor must at least be made to develop the intellectual faculties coincidentally in several directions. The question at issue at the present moment, I take it, is the number of main lines over which we can and are called on to travel. Hitherto only two have been generally recognized,—the line of literary studies, and the line of mathematical studies; but those of us who advocate the claims of natural science assert that there is a third, and that this is of great importance, as a large proportion of the work of the world is necessarily carried on over it. We assert, in fact, that however complete a course of literary and mathematical studies may be made, it is impossible by attention to these two branches of knowledge to educate one side of the human mind,—that side which has been instrumental in erecting the edifice of natural science, and in applying science to industry: the use of eyes and hands. I never tire of quoting from Kingsley's lecture to the boys at Wellington College (*Letters and Memories of his Life*, 3d abridged edition, p. 146, Kegan Paul & Co.): it puts the case into a nutshell:—

"The first thing for a boy to learn, after obedience and morality, is a habit of observation,—a habit of using his eyes. It matters little what you use them on, provided you do use them. They say knowledge is power, and so it is, but only the knowledge which you get by observation. Many a man is very learned in books, and has read for years and years, and yet he is useless. He knows *about* all sorts of things, but he can't *do* them. When you set him to work, he makes a mess of it. He is what you call a pedant, because he has not used his eyes and ears. . . . Now, I don't

mean to undervalue book-learning; . . . but the great use of a public school education to you is, not so much to teach you things as to teach you how to *learn*. . . . And what does the art of learning consist in? First and foremost in the art of observing; that is, the boy who uses his eyes best on his books, and *observes* the words and letters of his lesson most accurately and carefully, that is the boy who learns his lesson best, I presume. . . . Therefore I say that everything which helps a boy's powers of observation helps his power of learning; and I know from experience that nothing helps that so much as the study of the world about you."

Literary and mathematical studies are not a sufficient preparation in the great majority of cases for the work of the world: they develop introspective habit too exclusively. In future, boys and girls generally must not be confined to desk studies; they must not only learn a good deal about things, they must also be taught how to do things, and to this end must learn how others before them have done things by actually repeating—not by merely reading about—what others have done. We ask, in fact, that the use of eyes and hands in unravelling the meaning of the wondrous changes which are going on around us in the world of nature shall be taught systematically in schools generally; that is to say, that the endeavor shall be made to inculcate the habits of observing accurately, of experimenting exactly, of observing and experimenting with a clearly defined and logical purpose, and of logical reasoning from observation and the results of experimental inquiry. Scientific habits and method must be universally taught. We ask to be at once admitted to equal rights with the three R's: it is no question of an alternative subject. This cannot be too clearly stated, and the battle must be fought out on this issue within the next few years.

The importance of entering on the right course when the time comes that this claim is admitted—as it inevitably must be when the general public and those who direct our educational system realize its meaning—cannot be exaggerated. The use of eyes and hands—scientific method—cannot be taught by means of the blackboard and chalk, or even by experimental lectures and demonstrations alone: individual eyes and hands must be actually and persistently practised, and from the very earliest period in the school career. Such studies cannot be postponed until the technical college or university is reached: the faculties which can there receive their highest development must not have been allowed to atrophy through neglect during the years spent at school. This is a point of fundamental importance. At school the habit is acquired of learning lessons, of learning things from books; and after a time it is an easy operation to a boy or girl of fair mental capacity, given the necessary books, to learn what is known about a particular subject. One outcome of this, in my experience, particularly in the case of the more capable student, is the confusion of shadow with substance. "Why should I trouble to make all these experiments which take up so much time, which require so much care, and which yield a result so small in proportion to the labor expended, when I can gain the information by reading a page or so in such and such a text-book?" is the question I have often known put by highly capable students. They fail to realize the object in view,—that they are studying method; that their object should be to learn how to make use of text-book information by studying how such information has been gained; and to prepare themselves for the time when they will have exhausted the information at their dis-

posal, and are unprovided with a text-book, when they will have to help themselves. I am satisfied that the one remedy for this acquired disease is to commence experimental studies at the very earliest possible moment, so that children may from the outset learn to acquire knowledge by their own efforts; to extend infantile practice—for it is admitted that the infant learns much by experimenting—and the kindergarten system into the school, so that experimenting and observing become habits. The vast majority of young children naturally like such work, and it is to be feared that our system of education is mainly responsible for the decay of the taste with advancing years.

No doubt, just as literary excellence may be attained through the agency of one or other of several languages, scientific method may be inculcated in a variety of ways; and we may expect that, looking at the problem from various points of view, teachers will ere long devise courses suited to the requirements of scholars of different types. My views have been somewhat fully set forth in the "Reports to the British Association of the Committee on the Present Methods of Teaching Chemistry" (B. A. Report, 1888, 1889, 1890); but it is perhaps not superfluous to mention that the draft schemes which I have prepared are but outlines for the consideration of the competent teacher. On the present occasion, I may fitly bring my address to a conclusion by calling attention to a few simple experiments in illustration of the method of teaching of which I am an advocate. [The remaining portion of the address was illustrated with experiments.]

In the first place, I hold that, in order that children may acquire scientific habits, they should be led to look around them and take note of the various objects which present themselves to view. Lists of such objects having been prepared, their several uses having been as far as possible realized, and much simple information as to their origin, etc., having been imparted by reading lessons and practical demonstrations, a stage will be reached at which the children can themselves begin to determine the properties of common objects, generally by measurement. The measurement lessons in the first instance may be of the simplest kind. Much may be done with the aid of a boxwood scale divided into tenths of an inch on the one edge, and into millimetres on the other. With the aid of such a scale, children may learn to measure accurately, and may be taught the use of decimals and the relation between the English and the metric system. Obviously such work might well form part of the arithmetic lesson, and there can be no doubt that "practical arithmetic" lessons would often be far more easily mastered and be more interesting than are the dry problems of the books. It is easy also to take advantage of the opportunity afforded by these lessons to impress useful information of quite another character by such an exercise as the following, for example, which I suggest, however, merely by way of illustration, and not as in any sense novel: "Third-class passengers usually pay fare at the rate of one penny per mile. Ascertain from a railway time-table (Bradshaw) the fares to a number of the chief towns in England, Wales, and Scotland from London, and then calculate the distances in miles and kilometres (1 kilometre is equal to 1,000 metres)."

In the next place, the measurement lessons may take the form of lessons in weighing. I am of opinion that the disciplinary effect of teaching children to weigh exactly cannot be overestimated. It matters little what is weighed, provided that the weighing be done as accurately as the balance at disposal permits. Professor Worthington, in his invalua-

ble book "Physical Laboratory Practice" (Rivington's), has advocated the use of a simple balance costing only four shillings. However suitable this may be for demonstrating certain principles in physics, its use is to be entirely deprecated, in my opinion, for the purpose I have in view. I would urge most strongly that a far better instrument be procured, such as one of Becker's (of Rotterdam; English agents, Townson and Mercer) balances, costing, with suitable weights, about £3. In using such a balance, care has to be taken in releasing the beam and in bringing it to rest again; the pans must not be allowed to swing from side to side, but must be made to move gently up and down; the weights must be lifted on and off the pans with pincers, not touched by the fingers, so as to preserve them untarnished; and the weighing can, and in fact must, be made with considerable exactness. Finding that so many precautions have to be taken, and being severely reprimanded if careless in using such a balance, the child acquires a wholesome respect for the instrument, and soon becomes careful and exact. Weighing with the four-shilling pair of scales can afford no such discipline: their use in no way serves to correct the tendency (to quote a schoolboy phrase) to "muck about," unfortunately inherent in youth,—a tendency which can, I believe, be more successfully counteracted by proper measurement lessons than in any other way. The objection made to the purchase of so costly a balance for school use, I hold to be quite unwarrantable. Schools have no hesitation in charging for the use of books, and a charge of half a crown a year would more than cover their cost, if it were not possible to provide weighing appliances as part of the school furniture. I have been told that you cannot trust boys to use so delicate an instrument as that I advocate; and probably you cannot, if you wait until they have grown past control; but I believe that the difficulty will not arise if the instruction be given to children when quite young.

Haying learned to measure and weigh exactly, the children may be set to examine things generally. One of the best exercises that can be devised consists in weighing and measuring rectangular blocks of different kinds of wood, and then reducing the results so as to ascertain the weights of equal bulks. In this way the child is led to realize that in the several varieties different amounts of the wood-stuff are packed in the same space; that some woods are denser than others. The relative densities may then be calculated, taking the lightest as standard; and also their densities, i.e., the quantity of wood-stuff in the unit of volume, choosing several different units both of mass and of volume. The data thus obtained may be made use of in many ways, e.g., in setting arithmetical problems as to the weights of planks, etc., of various sizes; and lessons may at the same time be given as to the uses and characters of the different woods, the trees from which they are obtained, etc. In a similar manner, common liquids may be studied comparatively with the aid of a simple "density" bottle, constructed by filing a nick down the glass stopper of an ordinary two ounce narrow-mouth bottle, which may also be used in determining the relative density of solids of irregular shape. Children are thus put in possession through their own efforts of a series of numerical data whereby various materials may be characterized, and can be led to realize that it is possible to convey exact information by quoting these numerical data.

It is almost superfluous to point out that when the use of the balance has been learned, a stage is reached at which the study of levers and other simple mechanical powers may very properly begin; and that the determinations of

densities of liquids serve as an appropriate introduction to hydrostatics.

Measurements of another kind, which afford most valuable training, are those effected with the aid of a thermometer. It is most important that the use of this instrument should be generally understood, especially by women. It is astonishing how few people know the temperature at which water boils, and how mysterious an instrument to most is the clinical thermometer. Practice having thus been acquired in making measurements, and considerable knowledge having been gained of properties of common materials, I would advocate the quantitative study, especially by girls, of the effect of heat on vegetable and animal food materials, and subsequently on earthy substances and metals. Such exercises would serve as an appropriate introduction to the study of chemical change, which at this stage should be entered on more particularly with the object of developing the reasoning powers. I propose to give two examples by way of illustration. The one relates to the discovery of the composition of air; the other, to the discovery of the composition of chalk.

In considering air, it is the practice with most teachers, I believe, to explain, and in some cases demonstrate, how oxygen may be prepared, and how brilliantly many substances burn in it; air is then stated to be a mixture of oxygen with nitrogen in certain proportions, and certain proofs of this statement are advanced. Although much interested in the statements, and delighted at witnessing the firework displays which attend combustion in oxygen, the young student is not much the wiser for such lessons: a certain amount of "prepared food" has been put into his or her mouth, but no understanding acquired as to how it has been prepared, or whence it came. I advocate an entirely different course: I would not say one word as to what air is, or as to its having any thing to do with combustion, but would lead the scholar to discover that air is concerned in many common changes which apparently occur spontaneously, and to understand how the discovery that this is the case is made. Having directed attention to the manner in which animal and vegetable substances gradually decay, and are destroyed when burned, and to the rusting of iron, etc., I would propose that such changes should be experimentally investigated, and suggest that as iron rusts so readily when moist, the rusting of iron should be first examined: then would come the question, "But how is this to be done?" Having become so habituated to the use of the balance, and to express facts by numerical data, the student would appreciate the advice, "Let us see whether the balance will not aid us; let us endeavor to ascertain whether the iron gains or loses in weight during rusting." A clock-glass or saucer is therefore weighed; some iron borings or nails are put upon it, and the weight ascertained; and, as iron is known to rust more rapidly when wet, the borings or nails are wetted and set aside to rust. After several days, the rusted iron is dried in an oven and weighed: it is found that the weight has increased, whence it follows that something from somewhere has been added to the iron. Thus a clew has been gained, and, following the example of the detective in search of a criminal, this clew is at once followed up. "Where did the something come from? It might be the water; but is there no other possible 'offender'? Yes, the iron rusted in air." This suggests the experiment of exposing wet iron in air in such a way as to ascertain whether the air is concerned in the rusting. Some borings are tied up in a piece of muslin, and the bag is hung from one end of a piece of stout wire,

bent round at the opposite end, so as to form a foot; the wire is set upright in a dish full of water, and a large pickle-jar is inverted over it, with its mouth in the water. The iron is thus shut up over water along with air. Gradually the iron rusts, and concurrently the water rises in the jar, showing that the air is concerned, as no rise is observed in a comparison experiment without the iron. But after a time the water ceases to rise: measurement shows that only about one-fifth of the air disappears. Clearly, therefore, the air is concerned. The experiment is repeated, and the same result obtained; fresh iron is put into the residual air, and still no change results: hence it follows, that, although the air plays a part in the rusting of iron, the air as a whole is not active, but only one-fifth part of it, which serves to suggest that the air is not uniform, but has parts. Consider the importance of the lesson thus learned, the number of discoveries made by a few simple quantitative experiments, the insight into exact method which is gained by a thoughtful worker.

To pass to my second example, — the discovery of the composition of chalk. How is this to be effected? I would call attention to what is known about chalk by people generally, — what it is like, where it occurs, and what it is used for, — and ask whether there is no well-known fact connected with chalk which will serve as a clew, and enable us to apply our detectives' method. One of the great uses of chalk is for making lime, which is got by burning chalk. Is there any thing known about lime which shows that it differs from chalk? Yes, when wetted, it slakes and much heat is given out, while chalk is not altered by wetting; when the experiment is made quantitatively, lime is found to increase about 33 per cent in weight on slaking. Let us then study the conversion of chalk into lime by burning, and, as our unaided eyes tell us nothing, let us call in the aid of a balance. A weighed quantity of chalk is strongly heated, and is found to grow lighter; after a time, no further loss is observed, and, when this is the case, the loss amounts to, say, about 43 per cent; on repeating the experiment, the same result is always obtained, and therefore it cannot be an accident that the loss amounts to only about 43 out of every 100 parts of chalk. What conclusion are we to draw? Evidently that the stuff composing chalk consists of lime-stuff plus something else which is driven off when the chalk is burned. What is this something? Can't we catch it as it is given off? (We can, but the experiment is difficult, requiring special appliances, owing to the high temperature required to burn chalk in a close vessel). If not, is there no other clew which can be followed? Yes, there is. It is to be supposed that at an earlier stage in the experiments, attention will have been directed to the way in which discoveries were made in early times; to the fact that various substances were found to act upon each other, giving new substances; and that when a new substance was discovered its action on the previously known substances was studied; that in this way various acids were discovered; and that it was found out that these were powerful solvents of metals, earthy substances, etc., of chalk, among other substances. What happens to chalk when thus dissolved in an acid? The experiment is tried, and it is found that an air-like substance or gas escapes as the chalk dissolves. How does lime behave with acid? It is found on trial to dissolve, but no gas is given off. May it not be, then, that the gas which is given off when chalk becomes lime is also given off when chalk is acted on by acid? Let us find out how much gas is given off in this latter case. A weighed quantity of chalk is dissolved in

acid and the gas measured, a simple apparatus being used, like that figured in the last "British Association Report" (*Nature*, April 23, 1891). It is found, when several experiments are made, that, on the average, about 22,000 cubic centimetres of gas are given off per 100 grams of chalk; and chalk is thus shown to be characterized not only by the percentage of lime which it yields, but also by the amount of gas which it affords when dissolved in acid.

What is the weight of the gas that escapes? The experiment is carried out (by means of a very simple apparatus), and the all-important discovery is made that the weight of the escaping gas is just about what was lost on burning chalk. There can be little doubt, therefore, that the gas thus studied is "the something" which is given off when chalk is burned. If so, perhaps it may be possible to re-associate this gas with lime, and produce chalk. Lime is therefore exposed in an atmosphere of the gas, and the increase in weight determined; it is eventually ascertained that the lime increases in weight to the extent required on the assumption that it is reconverted into chalk; and on examining the product it is found to behave as chalk both when heated and when dissolved in acid. Thus the problem is solved, and it is determined that chalk-stuff consists of lime-stuff and chalk-gas. I employ these terms advisedly, and advocate their use until a much later stage is reached, when systematic nomenclature can be advantageously made use of.

In talking about chalk, it may be pointed out that chalk is believed to consist of skeletal remains and shells of sea-animals; and, when the composition of chalk has been ascertained, the suggestion comes naturally to examine shells. When their behavior on burning and towards acid is studied quantitatively, results are obtained which place it beyond doubt that they essentially consist of chalk-stuff. The chalk studies thus become of very great importance, and may be made to cover a wide field.

It is not to be denied that there are difficulties connected with such teaching as that I am advocating, but it is a libel on the scholastic profession to assert that the difficulties are insuperable. I am sure that in this case the old ever-true saying may be quoted, "Where there's a will there's a way." Such teaching has not yet been given simply because there must be less class-teaching, more individual attention, an adequate proportion of the school time must be devoted to the work, and properly trained, sympathetic teachers must be called in to give such instruction.

When scientific method is taught in schools, there will inevitably be a great improvement in school-teaching generally; it will be carried on in a more scientific manner, and new methods will be introduced. Indeed, I have already learned from a head master in whose school experimental science-teaching is receiving much attention, that the leavening effect on the teachers of some other subjects in the school is quite remarkable, and that they are clearly being led to devise more practical modes of teaching.

Photography and the lantern, also, are modern weapons of great power, which often enable us to clothe the dry bones of otherwise unattractive subjects with pleasing drapery. And here the parent can often intervene with great effect.

[Prof. Armstrong, in conclusion, drew attention to several "logs" kept by young children, illustrated with photographs, and insisted on the educational value of such work, owing to the opportunity which it afforded of directing attention to various matters of interest, and of impressing useful information on the memory.]